and what increase there has been is entirely attributable to home computer acquisition, not access in the workplace. As an illustration, in 1983, less than 1 percent of those without high school diplomas had computers in their homes. By 1990, the proportion had grown to 7 percent, and by 1999, it had increased to 22 percent. During the same 16-year period, access to computers at work did not rise above 10 percent. Clearly, there is a difference in computer acquisition between those who did not finish high school and those with more formal education, but there is an even greater disparity in the use of computers in the workplace. (See figure 8-19 and appendix table 8-30.) For more information on this subject, see the section on "Information Technologies and the Citizen" in chapter 9.

The Relationship Between Science and the Media: Communicating with the Public

Most of what most Americans know about science and technology comes from watching television or reading a newspaper. (See sidebar, "Where Americans Get Information about Science and Technology.") Thus, the media serve as a crucial conduit between the science and engineering community and the public at large.

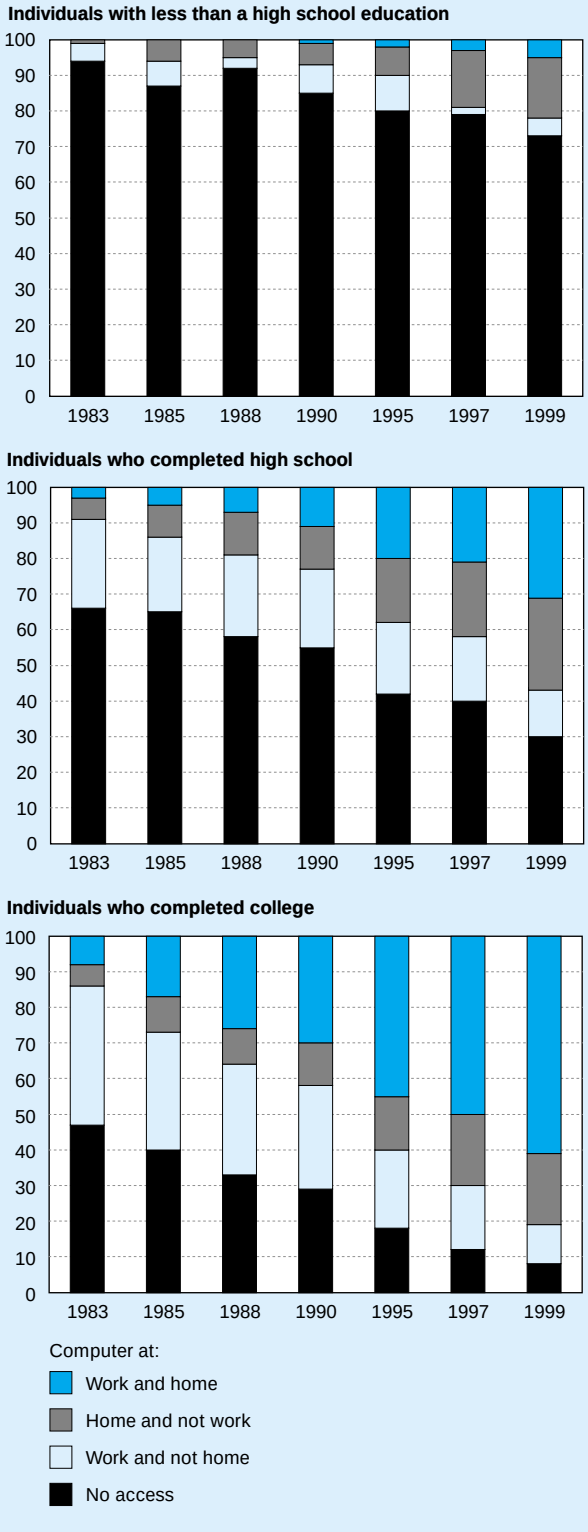
Findings from a recent study conducted by the First Amendment Center[25] revealed a general consensus that the science community and the press are missing opportunities to communicate with each other and with the public:

> [T]he frequent inability of science and the media to communicate effectively with each other seriously undermines science literacy among the general public. This, in turn, creates an electorate ill-prepared to make informed judgments about major issues related to science, health, and technology, such as global warming and human cloning, as well as multi-billion-dollar federal investments in research and development (Hartz and Chappell 1997).

The public needs to be informed about the importance of science and technology, because tax dollars fund a sizable portion of the nation's R&D enterprise—an estimated $66.6 billion in 1998. (See chapter 2, "U.S. and International Research and Development: Funds and Alliances.") The public should know what it is buying with that investment. In addition, the science and engineering community, which relies fairly heavily on public financing for both its employment and its education, is also dependent on the news media to inform the public about the work that it does.

The relationship between the media and the science and engineering community has been the focus of considerable

Figure 8-19.
Access to computers, by level of education: 1983–99 (selected years)



See appendix table 8-30. *Science & Engineering Indicators – 2000*

[25]All information in this section (unless otherwise specified) comes from the report *Worlds Apart: How the Distance between Science and Journalism Threatens America's Future* (Hartz and Chappell 1997). This report contains findings from a study conducted by Jim Hartz (a veteran television and print journalist who has covered science extensively) and Rick Chappell (associate director for science at NASA's Marshall Space Flight Center in Huntsville, Alabama). The Freedom Forum First Amendment Center is affiliated with Vanderbilt University and its Institute for Public Policy Studies.

Where Americans Get Information about Science and Technology

Television is the leading source of information about new developments in science and technology, followed by books and newspapers.* According to the 1999 NSF survey, each adult watches an average of about 1,000 hours of television per year; 42 percent of those hours are devoted to television news and 4 percent to shows about science.** (See appendix table 8-33.)

Men watch more science shows than women; the 1999 survey data indicate that men watch an average of 46 hours per year, compared with 38 for women. Those with more formal education and those who have taken more science and mathematics courses tend to watch more television shows devoted to science than those with less education, but the differences are not substantial. (See appendix table 8-33.)

Cable television subscribers watch significantly more science shows than those without cable. The 1999 data indicate that cable subscribers watch an average of 50 hours per year, compared with 20 hours for individuals without the service. (See appendix table 8-33.)

The most recent data show Americans reading an average of 178 newspapers, 11 news magazines, and 3 science magazines per year. (See appendix table 8-33.) However, the percentage of all adults who read a newspaper every day has been declining—from 62 percent in 1983 to 41 percent in 1999.*** (See appendix tables 8-34 and 8-35.) The decline is apparent at all education levels. (See figure 8-20.)

*In one survey, 40 percent of the respondents said they pay a lot of attention to programs about science and technology; 46 percent said they pay a lot of attention to news reports about science on evening news shows or programs such as *20/20* or *Nightline* (Roper 1996).

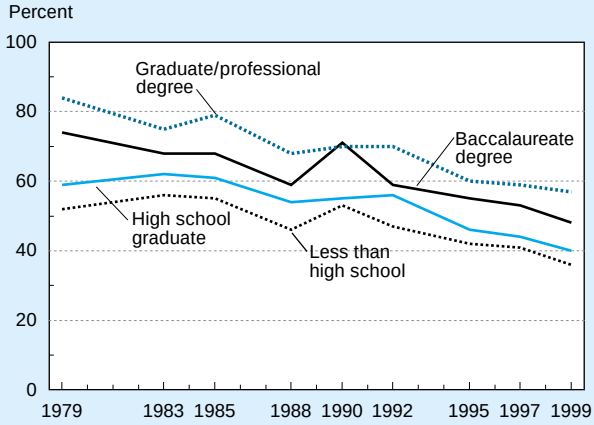
**Since respondents were asked to name the science shows they watch regularly or periodically, this is a credible estimate of viewership.

***A focus group study revealed that *Washington Post* readers spend an average of only 22 minutes per day reading the paper (Suplee 1999).

The 1999 data indicate that Americans visit a public library an average of 9 times per year, and they borrow an average of 11 books and 1 videotape during that time frame. Sixty-two percent of those surveyed bought at least one book during the preceding 12-month period, and 33 percent said that they bought at least one book about science, mathematics, or technology (including computer use). (See appendix tables 8-33 and 8-34.)

About three out of every five Americans visit a science museum, natural history museum, zoo, or aquarium at least once per year. Museum attendance is positively related to formal education and attentiveness to science and technology. (See appendix tables 8-34 and 8-36.)

Figure 8-20.
Percentage of the U.S. public reading a newspaper every day: 1979–99



See appendix table 8-35. *Science & Engineering Indicators – 2000*

scrutiny. Interest has grown in the past decade, probably because with the end of the Cold War, Federal support for R&D is not quite as solid as it once was. That is, R&D is facing stiffer competition among competing priorities within the Federal budget. (See chapter 2, "U.S. and International Research and Development: Funds and Alliances.")

To identify the problems and develop recommendations for improving the relationship between science and the media, the First Amendment Center conducted a survey wherein both journalists and scientists were asked the same series of questions.[26] (Because only about one-third of each group submitted completed questionnaires, these findings should be treated with caution.) In addition, the survey findings were discussed at a forum on the topic.[27] A report was then prepared that contains a comprehensive description of the issues and recommendations for improving the relationship between science and the media. (See footnote 25).

What Are the Problems?

Distrust of the Media

The survey revealed a lack of confidence in the press. Only 11 percent of the scientists reported having a great deal of confidence in the press, and 22 percent said they have hardly any. (Comparable percentages for the journalists were 35 per-

[26]Questionnaires were sent to 2,328 journalists, including (1) 1,036 individuals identified in the *Editor & Publisher* yearbook as editors, managing editors, or science correspondents or editors working at newspapers with circulations greater than 50,000 and (2) all 1,292 active members of the Radio-Television News Directors Association. For the scientists in the survey, 2,002 names were drawn randomly from the list of medical researchers of the American Medical Association and the membership lists of the American Geophysical Union, the American Physical Society, the Federation of American Societies of Experimental Biology, and the American Astronomical Society. About one-third of both the journalists and the scientists submitted completed questionnaires.

[27]The panel discussion was held on October 3, 1997, as part of a two-day event to commemorate the 40th anniversary of the launch of the Sputnik satellite.

Y2K Awareness and Concerns

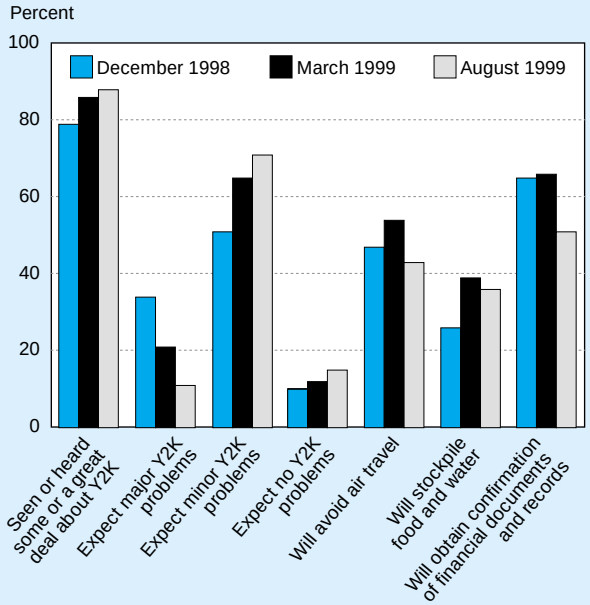
Media publicity about the Y2K problem seems to have worked. (Of course, the Y2K issue turned out to be a non-issue.) Data from several polls—including one conducted in December 1998, another in March 1999, and a third in August 1999—indicated

- A growing awareness of the Y2K issue, which refers to potential problems caused by computers not programmed to recognize dates after December 31, 1999. More than 85 percent of those polled in March and August 1999 said they had seen or heard "some or a great deal" about the so-called Millennium Bug, up from 79 percent in late 1998. (See figure 8-21.)
- A lessening of concern. The percentage of respondents anticipating major problems on January 1, 2000, fell from 34 percent in December 1998 to 21 percent in March 1999 to 11 percent in August 1999. However, concern remained over air travel, food shortages, and financial account accuracy. In August 1999,
  - 35 percent said it is likely that air traffic control systems will fail, down from 43 percent recorded three months earlier;
  - 35 percent said it is likely that food and retail distribution systems will fail (possibly causing grocery and other store shortages), down slightly from the previous surveys; and
  - 48 percent said that it is likely that banking and accounting systems will fail, down from 55 percent in March and 63 percent in December.
- A decrease in the number of people planning to take precautions. In August 1999,
  - 43 percent said they would avoid traveling on airplanes on or around January 1, 2000, down from 54 percent in March;
  - 36 percent said they would stockpile food and water, compared with 39 percent in March; and
  - 51 percent said they would obtain special confirmation or documentation of their bank account balances, retirement funds, or other financial records, down from 66 percent in the previous survey. (See figure 8-21.)

Most of those polled expressed:

- A high level of confidence (more than 80 percent in August 1999) in local, state, and Federal Government agencies' and large companies' ability to upgrade their computer systems before the end of 1999.
- Less confidence in other developed and industrialized countries' governments (49 percent)—and in small companies (65 percent, compared with 91 percent for large companies)—being able to meet the deadline; and
- Little confidence (less than 20 percent) in the governments of Third World or other less developed countries' ability to make the necessary software revisions.

Figure 8-21.
Public perception of and reaction to the "Year 2000 bug": 1998–99



SOURCE: *USA Today*/NSF/Gallup Poll,1999. "Americans and the Y2K Millennium Computer Bug."

Science & Engineering Indicators – 2000

cent and 4 percent, respectively.) Confidence in television media was even lower: nearly half (48 percent) of the scientists said they have hardly any confidence in it (compared with 27 percent for the journalists).[28] It is noteworthy that of all groups surveyed by the First Amendment Center (including the clergy, corporate leaders, the military, and even politicians), none was as distrustful of the news media as the scientists.

In addition, the media were faulted for failing to understand the process of scientific investigation, oversimplifying complex issues, and focusing on trendy discoveries:

- The vast majority of the scientists either strongly (52 percent) or somewhat (39 percent) agreed with the statement, "Few members of the news media understand the nature of science and technology, such as the tentativeness of most scientific discovery and the complexities of results." (Comparable percentages for the journalists were 23 percent and 54 percent, respectively.)

[28]Interestingly, the journalists' responses to several questions indicated a higher level of confidence in the scientific community than in their own professional community. Also, the public in general has relatively little confidence in the press and TV. (See figure 8-9 and appendix table 8-23.)

- More than half (56 percent) of the scientists either strongly or somewhat agreed with the statement, "Members of the news media rarely get the technical details about science and technology correct." (Only one-fifth of the journalists agreed or somewhat agreed with the statement.)
- About three-quarters of the scientists either strongly (30 percent) or somewhat (46 percent) agreed with the statement, "Most members of the news media are more interested in sensationalism than in scientific truth." (Comparable percentages for the journalists were 5 percent and 17 percent, respectively.) (See figures 8-22 and 8-23.)

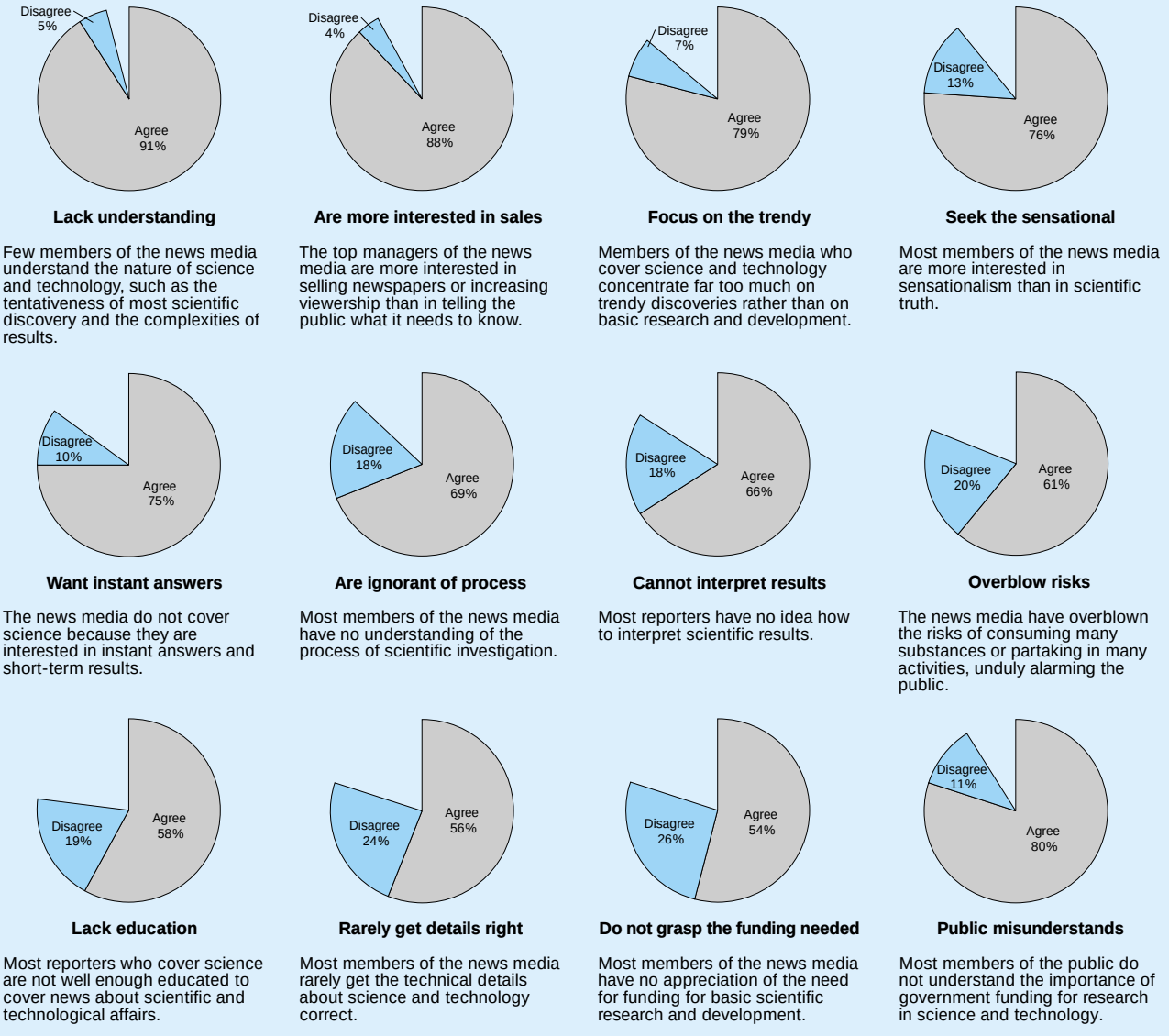
Perceived Lack of Interest in Science

News decisionmakers may decide not to cover science stories. Few editors have any formal training in science.[29] These "gatekeepers" may

- believe their readers or listeners are uninterested in science stories and will not be able to understand them;
- allow the bad experiences they may have had with high

[29]Although half the journalists who participated in the First Amendment Center survey had covered science, only 6 percent reported having science degrees.

Figure 8-22.
Scientists' agreement with various negative statements about the news media



NOTE: The percentage not accounted for in each of these charts represents those scientists who answered "neither agree nor disagree."

SOURCE: J. Hartz and R. Chappell, *Worlds Apart: How The Distance Between Science and Journalism Threatens America's Future* (Nashville, TN: Freedom Forum First Amendment Center, 1997).

Science & Engineering Indicators – 2000

school or college science courses to influence their decisionmaking;

- think that, because their publications or programs are devoting sufficient space or time to stories about medicine and health, they are doing an adequate job of covering science; and
- claim that science sections fail to attract advertisers.[30]

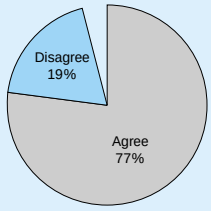
[30]It is widely assumed that people who read science news are not large purchasers of the type of consumer products most heavily advertised in newspapers. In addition, science sections of major newspapers have traditionally been supported by computer ads and the number of computer manufacturers has been shrinking (Suplee 1999).

Communication Barriers

Scientists tend to use technical jargon instead of plain English when discussing their work. Also, they have yet to master the "sound bite." They have a penchant for citing numerous qualifications when describing their findings, rather than summing up their research in one or two sentences. This communication style makes it difficult for science reporters to do their job.

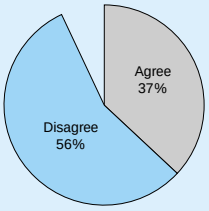
Scientists also have a reputation for not being very good at identifying what is newsworthy and relevant to readers or listeners. According to one reporter, "scientists are sometimes

Figure 8-23.
Journalists' agreement with various negative statements about the news media



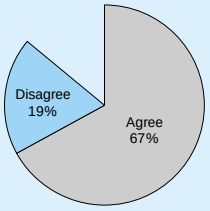
Lack understanding

Few members of the news media understand the nature of science and technology, such as the tentativeness of most scientific discovery and the complexities of results.



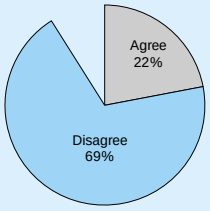
Are more interested in sales

The top managers of the news media are more interested in selling newspapers or increasing viewership than in telling the public what it needs to know.



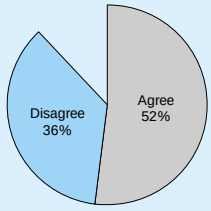
Focus on the trendy

Members of the news media who cover science and technology concentrate far too much on trendy discoveries rather than on basic research and development.



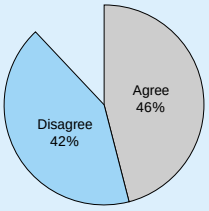
Seek the sensational

Most members of the news media are more interested in sensationalism than in scientific truth.



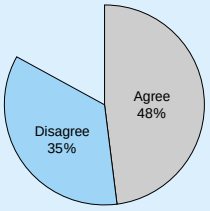
Want instant answers

The news media do not cover science because they are interested in instant answers and short-term results.



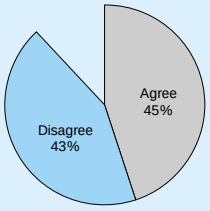
Are ignorant of process

Most members of the news media have no understanding of the process of scientific investigation.



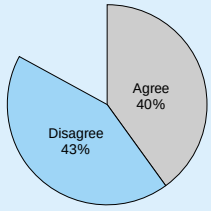
Cannot interpret results

Most reporters have no idea how to interpret scientific results.



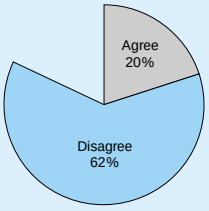
Overblow risks

The news media have overblown the risks of consuming many substances or partaking in many activities, unduly alarming the public.



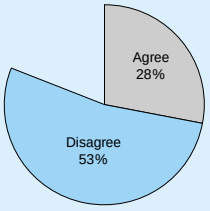
Lack education

Most reporters who cover science are not well enough educated to cover news about scientific and technological affairs.



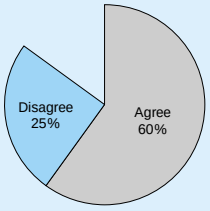
Rarely get details right

Most members of the news media rarely get the technical details about science and technology correct.



Do not grasp the funding needed

Most members of the news media have no appreciation of the need for funding for basic scientific research and development.



Public misunderstands

Most members of the public do not understand the importance of government funding for research in science and technology.

NOTE: The percentage not accounted for in each of these charts represents those journalists who answered "neither agree nor disagree."

SOURCE: J. Hartz and R. Chappell, *Worlds Apart: How The Distance Between Science and Journalism Threatens America's Future* (Nashville, TN: Freedom Forum First Amendment Center, 1997).

Science & Engineering Indicators – 2000

bad judges of their best stories" (P. Conti, as quoted in Hartz and Chappell 1997, 92). Therefore, the message to scientists should be:

> ...Two things...are vital and...found in nearly all good stories about science: relevance and context. Since so much of science is incremental, the reporter and the public need special help in placing research in the context of the big picture.…(Hartz and Chappell 1997, 93).

Most scientists are unaccustomed to discussing their work with anyone other than their peers or students. Also, in the past, scientists were often able to take funding for granted; that is, they rarely needed to justify and explain their work to the public. This may account for their lack of experience in communicating with lay audiences through speaking engagements, on television, on the radio, and in writing for the popular press.[31]

Scientists are often reluctant to talk to the press, and rarely do so.[32] Undoubtedly, some of this lack of media contact is related to the feelings of distrust discussed previously. Also, scientists may seem overly concerned with how they are perceived by their peers. One of the most frequently cited reasons for scientists' reluctance to talk to the press is the so-called Carl Sagan effect, that is, renowned scientist Carl Sagan was criticized by his fellow scientists who assumed that because Sagan was spending so much time communicating with the public, he must not have been devoting enough time to his research.[33] Another reason that may cause scientists to evade the press is a fear of being misquoted or having their work mischaracterized; in such cases, their colleagues would have no way of knowing whether the scientist or the reporter was at fault.

An Ill-Informed and Poorly Educated Public

Although scientists and journalists do not see eye-to-eye on several issues, both agree that there is a need for a better informed and educated public.[34] In the First Amendment Center survey, more than two-thirds of the journalists and more than three-quarters of the scientists strongly or somewhat agreed with the statement: "The American public is gullible about much science news, easily believing in miracle cures or solutions to difficult problems." Moreover, 60 percent of the journalists and 80 percent of the scientists strongly or somewhat agreed with the statement: "Most members of the public do not understand the importance of government funding for research" and therefore do not understand what they are getting from their investment in R&D. (See figures 8-22 and 8-23.)

The state of science education has been a major concern because scientific and technological advancements are having an increasingly pervasive impact on modern life. (See chapter 5, "Elementary and Secondary Education.") Both sets of respondents cited weaknesses in science education in their survey questionnaires.[35] Not only does the education system not do as good a job as it should in imparting basic scientific knowledge, it also lets too many students slide through without developing good critical thinking skills, skills crucial in a society in which informed decisionmaking is becoming increasingly important and more complex. (See the section "Belief in the Paranormal or Pseudoscience.")

What Should Be Done To Improve the Relationship?

Both scientists and journalists participating in the First Amendment Center project demonstrated a willingness to improve their working relationship. More than three-quarters of the scientists said they would be willing to take a course designed to help them communicate better with journalists and the public, and more than 90 percent said they would be willing to participate in an ongoing dialogue with members of the news media.

After reviewing the survey findings and listening to ideas exchanged at the forum, participants developed the following recommendations, which were included in the First Amendment Center report:

- Scientists and reporters should engage in an ongoing dialogue with each other to learn how both can do a better job of communicating with the public.
- Professional societies and other organizations representing scientific disciplines should maintain Web sites that contain the telephone numbers and e-mail addresses of scientists available to talk to the press. These Web sites should also contain information useful to the press and the general public and should have links to a master Web site main-

[31]The President's Science Advisor, Dr. Neal Lane, often speaks and writes about "the importance of scientists getting out of their labs, off their campuses, away from their computers, and into a dialogue with the American public." According to Dr. Lane, "A partial solution to this disconnect [between the science community and the public] is to educate scientists on how to be better communicators not only about their particular work but about the role and value of science and technology to society" (Neal Lane, speech before the Arlington Rotary Club, July 25, 1996).

[32]Nearly one-fourth of the scientists who participated in the First Amendment Center survey said they had never been interviewed or written about in a science news story; 45 percent answered "every few years." In a recent article, one host of a talk show in the United Kingdom described what a difficult time he had getting scientists to appear on his program: "The excuses varied but I discovered a deep-seated suspicion among British scientists about how they would be received by a nonscientific audience" (Bragg 1998).

[33]Sagan "was actually denied membership in the National Academy of Sciences, in part because many of the members felt it was unseemly for him to be so popular, so well-spoken, to get so many lucrative book contracts" (Hartz and Chappell 1997).

[34]The state of science education was the most frequently mentioned topic among the comments provided by the scientists on their questionnaires. A number of scientists have even observed, with dismay, what may be described as a cultural bias against science literacy. One scientist, who is also a Congressman, noted that it has "become fashionable to be ignorant about science" (The American Institute of Physics 1999).

[35]According to the NSF survey, a majority of Americans believes that the quality of science and mathematics education in U.S. schools is inadequate. But that proportion has been falling. Three-quarters of those surveyed held that view in 1992 and two-thirds did in 1999. (See appendix table 8-37.) In another poll, 57 percent of the respondents strongly agreed, and 28 percent somewhat agreed, with the statement that "unless we put more emphasis on science in the schools, we won't have the trained people we will need for life in the twenty-first century" (Roper 1996).

tained by either the American Association for the Advancement of Science or the National Academy of Sciences.

- Each article published in a scientific journal should include a brief summary—written in plain English—that contains the author's major findings and a brief explanation of the research's importance and relevance.
- Future scientists should be required to take undergraduate courses in communications, and future journalists should be required to take courses in science (to gain a better understanding of the scientific process).
- Journalists should approach what may appear to be groundbreaking research with caution, paying heed to the peer-review process, before reporting on the research.
- The scientific community should train spokespersons for each discipline, and scientists should welcome opportunities to talk about their work with the press and the general public.[36]

Belief in the Paranormal or Pseudoscience[37]

Does it matter if people believe in astrology, extrasensory perception (ESP), or that aliens have landed on Earth? Are people who check their horoscopes, call psychic hotlines, or follow stories about alien abductions just engaging in harmless forms of entertainment? Or, are they displaying signs of scientific illiteracy?

Concerns have been raised, especially in the science community, about widespread belief in paranormal phenomena. Scientists (and others) have observed that people who believe in the existence of paranormal phenomena may have trouble distinguishing fantasy from reality. Their beliefs may indicate an absence of critical thinking skills necessary not only for informed decisionmaking in the voting booth and in other civic venues (for example, jury duty[38]), but also for making wise choices needed for day-to-day living.[39]

Specific harms caused by paranormal beliefs have been summarized as:

- a decline in scientific literacy and critical thinking;
- the inability of citizens to make well-informed decisions;
- monetary losses (psychic hotlines, for example, offer little value for the money spent);
- a diversion of resources that might have been spent on more productive and worthwhile activities (for example, solving society's serious problems);
- the encouragement of a something-for-nothing mentality and that there are easy answers to serious problems, for example, that positive thinking can replace hard work; and
- false hopes and unrealistic expectations (Beyerstein 1998).

For a better understanding of the harms associated with pseudoscience, it is useful to draw a distinction between *science* literacy and *scientific* literacy. The former refers to the possession of technical knowledge. (See "Understanding Terms and Concepts" in the section "Public Understanding of Science and Technology.") Scientific literacy, on the other hand, involves not simply knowing the facts, but also requires the ability to think logically, draw conclusions, and make decisions based on careful scrutiny and analysis of those facts (Maienschein 1999; Peccei and Eiserling 1996).

The amount of information now available can be overwhelming and seems to be increasing exponentially. This has led to "information pollution," which includes the presentation of fiction as fact. Thus, being able to distinguish fact from fiction has become just as important as knowing what is true and what is not. The lack of this ability is what worries scientists (and others), leading them to conclude that pseudoscientific beliefs can have a detrimental effect on the well-being of society.[40] (See "An Ill-Informed and Poorly Educated Public" in the section "The Relationship between Science and the Media: Communicating with the Public.")

Belief in the Paranormal: How Common Is It?

Belief in the paranormal seems to be widespread. Various polls have shown that

- As many as one-third of Americans believe in astrology, that is, that the position of the stars and planets can affect people's lives (Harris 1998, Gallup 1996, and Southern Focus 1998). In 1999, 7 percent of those queried in the NSF survey said that astrology is "very scientific" and 29 percent answered "sort of scientific." (See figure 8-24.) Twelve percent said they read their horoscope every day

[36]One journalist advises scientists to "track the ways that the popular media report basic research and interpret its value." According to the writer, "scientists can get clues [about how to improve] their communication skills with the media by noting what editors choose to cover, what they dismiss as uninteresting, and, more subtly, how they sometimes fail to make connections or provide perspective" (Lewis 1996).

[37]Pseudoscience has been defined as "claims presented so that they appear [to be] scientific even though they lack supporting evidence and plausibility." In contrast, science is "a set of methods designed to describe and interpret observed and inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation" (Shermer 1997). Paranormal topics include yogic flying, therapeutic touch, astrology, fire walking, voodoo magical thinking, Uri Geller, placebo, alternative medicine, channeling, Carlos hoax, psychic hotlines and detectives, near death experiences, UFOs, the Bermuda Triangle, homeopathy, faith healing, and reincarnation (Committee for the Scientific Investigation of Claims of the Paranormal).

[38]Because of several well-publicized court cases, considerable attention has been focused on the role of science in the courtroom and the ability of judges and juries to make sound decisions in cases involving highly complex, science- or technology-based evidence. (See Angell 1996 and Frankel 1998.)

[39]A fairly common example that reflects a dearth of critical thinking skills is the number of people who become victims of get-rich-quick (for example, pyramid) schemes.

[40]According to J. Randi, "acceptance of nonsense as mere harmless aberrations can be dangerous to us. We live in an international society that is enlarging the boundaries of knowledge at an unprecedented rate, and we cannot keep up with much more than a small portion of what is made available to us. To mix our data input with childish notions of magic and fantasy is to cripple our perception of the world around us. We must reach for the truth, not for the ghosts of dead absurdities" (Randi 1992).